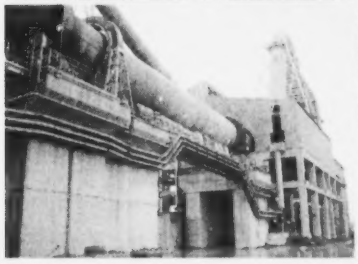
Industrial Minerals in British Columbia
2006 Review



Information Circular 2007-2

BRITISH COLUMBIA
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Ministry of Energy, Mines and Petroleum Resources

The Best Place on Earth

INDUSTRIAL MINERALS IN BRITISH COLUMBIA - 2006 REVIEW

by Simandl, G.J., Irvine, M.L., Grieve, D., Lane R., Wojdak,P., Madu, B., Webster, I., Northcote, B. and Schroeter, T.

British Columbia Ministry of Energy, Mines and Petroleum Resources

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COVER PAGE PHOTOS (FROM TOP TO BOTTOM):

- Detailed view of the Lafarge Canada Cement plant in Richmond, British Columbia. This plant has a capacity of 1.15 million tonnes of cement per year.
- Alumina-rich rock mined by Pacific Bentonite Inc in the Hat Creek area. This material is used in cement manufacturing, landscaping, baseball diamond construction and other applications.
- Golden Rock Product Ltd produces attractive flagstone from the Upper Aldridge Formation near Kimberley, southeast British Columbia.
- The president of Jade West Resources Ltd, Mr. Kirk Makepeace, displaying a spectacular nephrite boulder from Kutcho Creek area with an estimated value of approximately one million dollars.

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EXECUTIVE SUMMARY

Industrial minerals are commonly defined as: "*Any rock, mineral, or other naturally occurring substance of economic value, exclusive of metallic ores, mineral fuels and gemstones*". For the purpose of this paper, jade (nephrite) is also covered. As a group industrial minerals are the third most important solid mineral product in British Columbia after metals and coal. They are particularly notable because they support a number of value-added processing plants and industries within the province. This report is a summary of industrial mineral production, processing and exploration activity in British Columbia during 2006. It also identifies new development opportunities.

Industrial minerals are an increasingly significant component of international trade and BC has a strategic position on the west coast of North America to provide easy access many of these markets (Figure 1). The Province has a well-developed transportation and industrial infrastructure in the south. It also has deep-water ports and a well-maintained all-weather highway system that permits efficient long distance trucking. Rail lines link British Columbia's industrial centers to terminal points across Canada and the USA.

British Columbia's construction aggregate and industrial mineral production for 2006 is estimated to total more than $675 million[1]. Cement is projected to account for approximately $320 million, sand and aggregate for $190 million and stone for $78 million. The projected value of all other industrial minerals combined is $82 million (Figure 2), with sulphur being the major component[2].

The most economically significant industrial minerals produced in BC are: magnesite, white calcium carbonate, limestone, silica, dimension stone, gypsum and sulphur. Commodities produced in lesser quantities include jade (nephrite), magnetite, dolomite, barite, volcanic cinder, pumice, flagstone, clay, tufa, fuller's earth and zeolites.

Industrial minerals are essential components for the chemical, electronic, glass, pulp and paper and refractory industries, environmental rehabilitation and soil conditioning. Across the Province, there are more than 40 mines or quarries and at least 20 major plant sites where upgrading of industrial minerals into value-added products takes place. Selected industrial mineral mining operations are shown on Figure 3, and processing plants are depicted on Figure 4. Most of these operations are concentrated close to existing infrastructure and markets.

Figure 1. Strategic geographic location of British Columbia.

In British Columbia, there are more than 2000 sand and gravel pits, of which more than a third are active at least seasonally. About 50% of BC's aggregate production is used within the greater Vancouver region. Recently identified opportunities include the export of aggregate to California. This market is targeted by several well-established coastal producers and by a number of junior companies advancing new projects. Two of these new high profile projects, Orca and Swamp Point, located on Vancouver Island and near Prince Rupert respectively, anticipate shipping their products in 2007.

Cement is one of the building blocks of the BC economy. Given the current demand on the west coast of North America, it is possible that the two large producers in BC will increase their cement production capacity or that another major cement-producer will become established in the province. Since cement became an international traveler, it is also possible that future increases in local demand for cement will be satisfied by imports from Asia. Most of the large cement producers are investing in China and other

1 This is a conservative projection based on 2005 estimates published by Natural Resources Canada and on 2006 growth rates and cost increases reported in the United States.

2 Natural Resources Canada does not provide a detailed breakdown of production value for a number of individual industrial minerals as a means of protecting confidentiality of the data provided by the producers

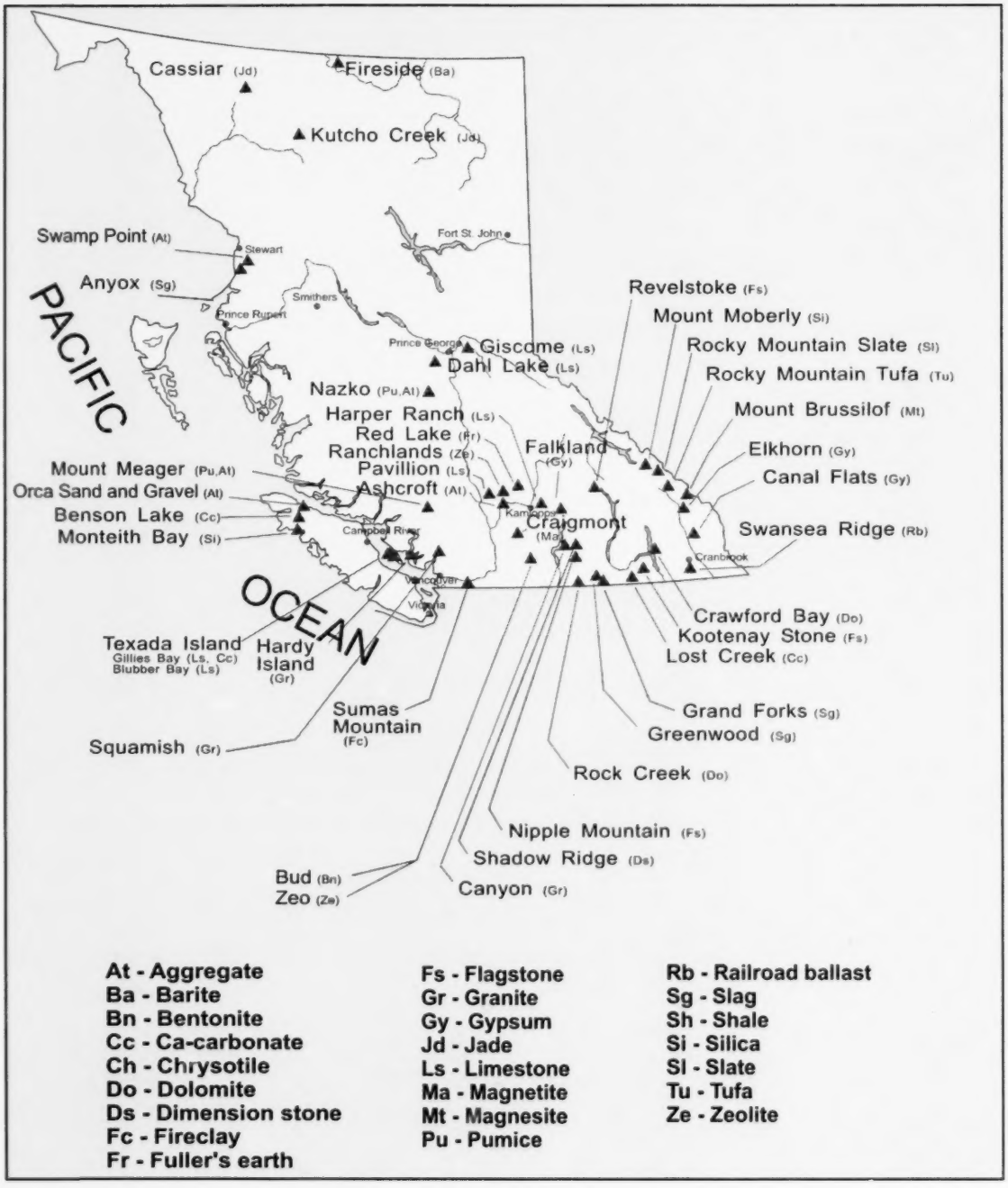

Figure 3 Selected industrial mineral mines in British Columbia.

Asian countries where growth rates in the cement market are in the double digits.

UNTAPPED INDUSTRIAL MINERAL RESOURCES

British Columbia has a large untapped industrial mineral resource base. It has an excellent geological potential to host over 40 industrial mineral commodities and there are over 2400 industrial mineral occurrences identified in MINFILE, an interactive, digital mineral-deposits database for the province. This database is available free of charge on the Internet: <www.em.gov.bc.ca/Mining/Geolsurv/Minfile/>. The British Columbia Ministry of Energy, Mines and Petroleum Resources website also contains selected technical papers describing specific industrial mineral deposits <www.em.gov.bc.ca/mining/Geolsurv/IndustrialMinerals/default.htm>. Deposit models for selected industrial mineral and gemstone deposit types specific to British Columbia, but also applicable elsewhere, are described in Open File 1999-10 (Simandl *et al.* 1999).

REVIEW BY COMMODITY

Sulphur

West Coast Energy Inc, Petro-Canada Inc, TransCanada Midstream and Amoco Canada Petroleum Company Limited produce sulphur, a byproduct of natural gas, at a number of processing plants in the northeast of the province. Liquefied SO_2 and sulphuric acid are produced at Cominco's smelter in Trail. Sulphur production in BC peaked in 1998 when it reached 941 000 tonnes, but it had fallen slightly to 853 820 tonnes by 2005. This may be due, in part by efforts of oil and gas-producing companies in Western Canada Sedimentary Basin to inject CO_2 and H_2S underground. About 620 000 tonnes of sulphur were produced from January to September 2006. The average price for the sulphur in 2006 is expected to be lower than $41.20/tonne, the average price for the 2005 sulphur production.

Gypsum

BPB Inc forecast its 2006 production at 460 000 tonnes of gypsum from its Elkhorn quarries near Windermere in the southeastern part of the province (Figure 3). A few years ago, the company drilled 98 holes, which indicated a resource of 16.7 million tonnes of gypsum on its Koot property, northeast of Canal Flats. More recently BPB Inc completed a successful drilling program on Elkhorn West gypsum deposit, located immediately west of its Elkhorn quarry site. These new reserves at Elkhorn West will postpone the need for development of Koot deposit at least by 10 years.

Georgia Pacific Canada Inc is expected to produce approximately 175 000 tonnes gypsum from its Four J mine near Canal Flats. Georgia Pacific ships about 100 000 tonnes of gypsum annually from its Four J quarry to its wallboard plant near Edmonton, Alberta, and the balance is sold for cement production or other applications. Georgia-Pacific received a permit for a bulk sampling of their Lussier River deposit and is expected to go ahead with that work. Both BPB Inc and Georgia Pacific operate wallboard plants in the Vancouver area.

Lafarge Canada Inc mined approximately 6000 tonnes of gypsum from its Falkland pit for its Kamloops cement plant. Falkland production was supplemented by gypsum supplied from BPB's Elkhorn deposits.

Eagle Plain Resources conducted a drilling program on their Coyote deposit, located approximately 70 km northeast of Canal Flats, in southeast British Columbia, and in November 2006 they optioned the property to CGC Inc.

Currently, British Columbia is a net energy importer. Most of the newly proposed electricity generating projects aiming to bridge the gap between BC energy needs and supply are typically hydro, wind or tidewater-powered. If coal-fired or co-generation (waste & coal) plants were permitted in the province, then synthetic gypsum derived by flue gas desulphurization could potentially replace some of natural gypsum which is satisfying the existing markets (Simandl, 2006).

Magnesite, Magnesia and Magnesium Metal

Magnesite, olivine and serpentine belong to the group of 'dual minerals' as defined by Simandl (2002a), as they may be used either as industrial minerals or as metal ores. Baymag Inc produces magnesite at its Mount Brussilof operation at a rate of about 200 000 tonnes annually. The company had two plant sites in Exshaw, Alberta. The first site, containing an old converted lime kiln produced sintered magnesia and was recently shut down. The second site houses a 50 000-tonne capacity, multiple hearth furnace, vertical-kiln, dedicated to specialty calcined MgO and an electrofusing installation. Calcined magnesia is the main product. There was no production of fused magnesia in 2006. Baymag Inc's parent company invested in China, and fused magnesia from Baymag's plant in Exshaw is no longer required. Baymag also started to sell crushed white magnesite for landscaping applications; however, that market remains limited.

There was no exploration during 2006 on the other major magnesite deposits in British Columbia described by Simandl (2002b). The short-term potential for use of the magnesite from these deposits appears limited, because of the Chinese dominance of magnesium metal and refractory magnesia markets. Even the largest and lowest cost magne-

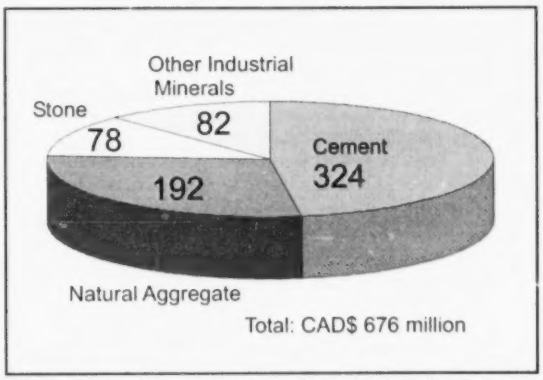

Figure 2. Value of Industrial Mineral Production in British Columbia total CAD$676 million; Preliminary estimates for 2006.

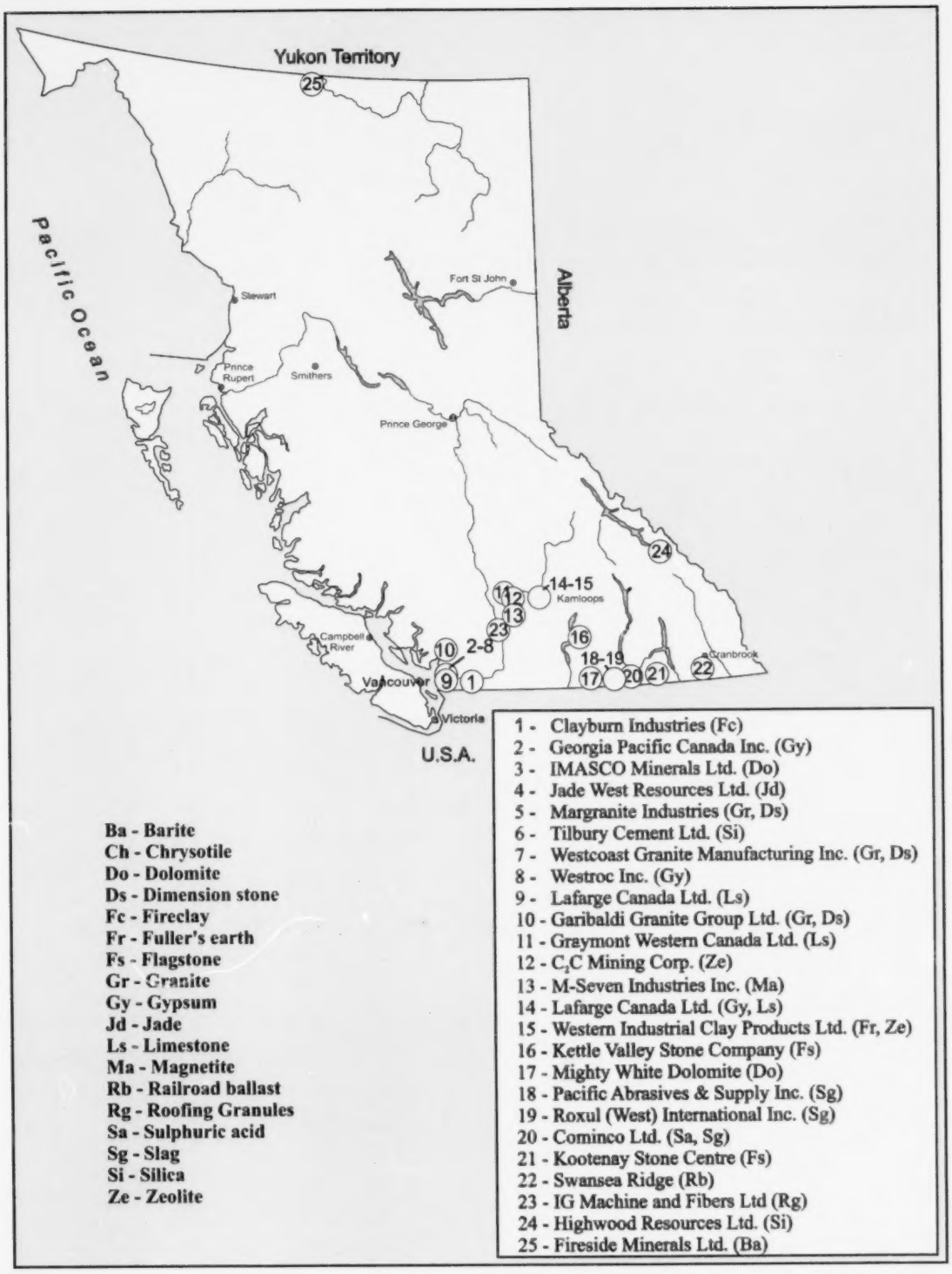

Figure 4 Selected industrial mineral processing plants in British Columbia.

sium producer in western world, the Norsk Hydro Canada Inc plant in Becancour, Quebec, is under pressure and may close (Anonymous, 2006). Politics may have a tremendous effect on the economic potential of British Columbia magnesite deposits; for example, sanctions related to North Korea's nuclear tests prevent Korean magnesite from reaching western markets. If Chinese exports were reduced and/or the prices of the Mg-metal increased, British Columbia's magnesite deposits, such as Mount Brussilof, would automatically become prime development targets to insure sufficient refractory magnesia and magnesium metal production. Brucite is also a potential important ore of magnesium and a source of magnesia. However, the potential of the province remains to be established (Simandl *et al.* 2006).

Leader Mining International Inc, through its wholly owned subsidiary North Pacific Alloys Limited, owns a magnesium-rich ultramafic body near Hope, east of Vancouver. This olivine-rich body may have industrial mineral applications, but it is currently considered by the company as a potential ore of magnesium metal. The company commissioned Aeroquest Limited to fly a geophysical survey over its claims, which identified several magnetic and electromagnetic anomalies. These anomalies are not expected to be directly related to magnesium metal mineralization; however, they could be significant from the base and precious metal exploration perspective.

Figure 5. Gillies Bay ship loading facility, Vancouver Island; Texada Quarrying Ltd (photo by Bruce Clague).

Limestone

The largest limestone production centre in the province is located on Texada Island (Figure 3), from which two quarries, Gillies Bay and Blubber Bay ship over 6 million tonnes annually. Customers for the limestone products are located in British Columbia, Washington, Oregon and California for cement, chemical, agricultural and construction use. Both operations currently have excess capacity and are aggressively marketing to the Vancouver area and the United States.

In 2005, about 5.6 million tonnes of rock was quarried from Gillies Bay alone, which is operated by Texada Quarrying Ltd (subsidiary of Lafarge Canada Inc), and the production for 2006 is expected to be higher. A few years ago, Texada Quarrying Ltd invested $10 million in an aggregate crushing plant and started shipping crushed rock as far as Los Angeles and San Diego, California and in 2005 it purchased a 4000 tonne per hour, single quadrant, shiploader (Figure 5). This shiploader can load a Panamax ship in 20 hours without the need to move the vessel. Texada Quarrying Ltd plans to construct a 2.4 km long, overland conveyor belt to reduce on site transportation costs. In the past basaltic dikes were a waste product but now these dikes and granitic rock will be crushed and sold as high quality aggregate products.

Ash Grove Cement Corporation upgraded their Blubber Bay crushing plant in 2002. Approximately 600 000 tonnes of limestone rock are expected to be shipped from Blubber Bay in 2006. Numerous pulp mills, three cement plants and two lime plants in British Columbia process limestone. Many of the mills normally produce their own lime.

Graymont Western Canada Inc's Pavilion Lake limestone quarry and lime plant, near Cache Creek, has a capacity of about 190 000 tonnes of lime annually. This plant is located on the Ts'kw'aylaxw First Nation reserve lands. A 40-year agreement between the two partners was signed earlier this year.

The Chemical Lime Company operates a lime plant in Burnaby and raw material for this plant is provided by Texada Quarrying. Most of the lime is used in mining-related environmental applications and in the pulp and paper industry, but the company also produces agricultural lime. The Chemical Lime Company also purchased Pacific Lime Products (1997) Ltd (100% of shares) in early 2006. It plans to start shipping product from this site in late 2006.

A number of exploration programs for limestone were underway during 2006. Graymont Western Canada Inc drilled 10 holes at its Pat group of claims located adjacent to the Pacific Lime Products Ltd [recently acquired by Chemical Lime Co] limestone quarry near Giscome, in the Prince George area. Pacific Lime was selling small quantities of limestone to pulp mills in the region. There was no production at this quarry in 2006, however, signs that some of the stockpiled material was shipped out in 2006 were visible during a field visit. Northrock Industries Ltd provided a limited amount of limestone from its Dahl Lake quarry for riprap and landscaping.

Graymont Western Canada Inc maintained its mineral tenure on Vancouver Island in good standing. They include the chemical limestone Var quarry, on Rupert Inlet near Port Hardy, and the Nimkish Lake limestone property. Lehigh Northwest Cement Limited drilled its Texada Limestone (also called Davie Bay) deposit on Texada Island.

Double Star Resources operated a major sampling and geophysical program on their limestone deposits located near Port Alice on Vancouver Island. Pan Pacific Aggregates Plc continues to promote the development of its super

quarry on the Sunshine Coast and one of the commodities listed on company documents is limestone.

Crushed Stone and Aggregate

British Columbia has the two largest aggregate operations in Canada and numerous smaller ones. Texada Quarrying Ltd is Canada's biggest aggregate operation and crushed rock is the natural by-product of their agricultural, chemical and filler grade limestone production. The company spent $2.5 million during 2006 just on two large hauling trucks and an excavator. By 2007, Texada Quarrying plans to optimize its transloading capacity, which will provide efficient service to clients such as Quinsam Coal Corporation and some of the sand and gravel operations.

Canada's second largest aggregate producer is Construction Aggregates Ltd's operation in Sechelt. The company invested heavily to increase its productivity in 2005 and in 2006 it will spend an additional $4 million to double its primary surge capacity and increase its screening capacity.

Construction Aggregates Ltd's Producers Pit which supplies about 2.2 million tonnes of sand and gravel to the Victoria area invested over $2 million dollars in 2005 on new mobile equipment, in spite of the fact that this operation is expected to close by 2007. The company's Sechelt operation plans to absorb up to a million tonnes of the lost production when the Producers pit closes.

Shipments of crushed stone from Texada Island and other coastal sources are making inroads into the Vancouver, Seattle, San Diego, San Francisco and Los Angeles markets. Exploration for traditional construction materials to tap these markets along the British Columbia coastline has resulted in number of exploration and mine development projects.

Several junior companies are planning to imitate the success of the Construction Aggregates Ltd's operation in Sechelt and to compete in California's aggregate market. For example, Polaris Minerals Corporation, in cooperation with Namgis First Nation, is currently developing their Orca project located 3.8 km from Port McNeil (Figure 6). This deposit is reported to have reserves of 121 million tonnes and there is a planned production capacity of 6 million tonnes per year. The project requires US$94.5 million development capital for the quarry and for the Richmond terminal in California

Ascot Resources Ltd was granted a permit which allows it to begin development of its Swamp Point aggregate deposit (Figure 7), located 50 kilometres south of Stewart. Construction for the first phase of production started in October 2006. The company indicates that they have 18 years of reserves at a maximum capacity of 3.3 million tonnes per year. Reported capital cost of the project is $27.5 million dollars.

Although there is recent high-demand for aggregate products, a number of the new projects under development will also have to compete with established producers. Lehigh Northwest Cement Limited is considering several new projects. Currently there are at least twenty aggregate sites in the permitting process in British Columbia and these include both new projects as well as established producers increasing their reserves and production capacity.

Basalt, diabase and gabbro are preferred materials for railway ballast in western Canada and therefore railway companies operate a number of ballast quarries in British Columbia. Railway ballast stockpiles, produced in 2005 from the Canadian National Railway Giscome basalt quarry, were substantially reduced in 2006. Canadian Pacific Railway mined, crushed and shipped railroad ballast

Figure 6. Orca sand and gravel quarry, on the east coast of Vancouver Island, is a joint venture between Polaris Mineral Corporation and the Namgis First Nations.

Figure 7. Swamp Point Project targets shipments of aggregate to coastal areas of western USA. (photo by Brian Grant).

from its Swansea Ridge gabbro quarry south of Cranbrook. Information is not available about the Walhachin quarry of Canadian Pacific. Ballast stockpiles at the Canadian National Railway Ahbau basalt quarry are largely diminished. No new production took place at either of the two quarries. Canadian National Railways is able to operate, as needed, at least 6 other railroad ballast operations, including McAbee (near Ashcroft), Boulder (near Clearwater), Taverne (near Tete-Jaune), Pacific (east of Terrace) and Kwinitsa (Mile 40 on Skeena).

Teko pit, southwest of Taylor near Ft St. John is a major aggregate crushing operation, supplying material mainly for the oil and gas sector in northeastern BC (road metal, *etc*).

For additional information on the BC aggregate industry, major sand and gravel operations are listed on the website of the British Columbia Aggregate Producers Association at <http://www.gravelbc.ca/members/member_list.html>.

White Calcium Carbonate

White, high-calcium carbonate is produced from deposits on Texada Island, the Vananda deposit operated by Imperial Limestone Co. and Gillies Bay operated by Texada Quarrying. IMASCO Minerals Inc also produced white calcium carbonate from Benson Lake, Vancouver Island and from the Lost Creek deposits, near Salmo, BC. White calcium carbonate has a variety of uses, including those for paper, paint and plastic filler production.

Omya Canada Inc was active during 2006 and carried out exploration on its Kinman Creek property near Nimkish Bay, Vancouver Island.

Dolomite

Dolomite or dolostone is quarried by IMASCO Minerals Inc at its Crawford Bay mine on Kootenay Lake and by Mighty White Dolomite Ltd near Rock Creek. Dolomite is used for soil conditioning, white ornamental aggregate, stucco and roofing, fine aggregate and in synthetic marble products.

Ash Grove Cement started to produce limy dolostone from a deposit adjacent to their main pit (# 7) on Texada Island (Figure 3). The production for 2006 is expected to exceed 45 000 tonnes.

Homegold Resources Ltd continued exploration work on its Jeune Landing property near Port Alice on Vancouver Island. Pan Pacific Aggregates Ltd proposes to construct and operate a quarry on the Sechelt Peninsula, approximately15 km northwest of Sechelt. Dolomite is one of many rock types occurring on this property, however, detailed data regarding ore reserves is unavailable. Pan Pacific submitted a pre-application for a proposed mine development to the Environmental Assessment Office in November, 2005. A recent review of dolomite resources in Coastal areas of British Columbia is provided in Simandl *et al.* (2006a).

Silica

In 2005 Dynatec Corporation sold its western Canadian mineral operations, including the Moberly silica mine and the related processing plant to Heemskirk Consolidated Ltd. In 2006, Heemskirk Canada Ltd, a subsidiary of Heemskirk Consolidated Ltd, expects to ship approximately 80 000 tonnes of silica from its Moberly mine and plantsite, mainly to Lavington, British Columbia. In the past, this operation also shipped lump silica to Springfield, Oregon, and other destinations for silicon metal and ferrosilicon production; however, since the collapse of the silicon and ferrosilicon industry in United States in the late nineties, these shipments have stopped. The Horse Creek silica mine, owned by Metaltech of Seattle and operated by Nugget Contracting Ltd, has remained idle since the 1998 shutdown of the Wenatchee metallurgical grade silicon and ferrosilicon plant.

The future of North American silicon and ferrosilicon industries appears bleak in the short term due to competition from low cost, Chinese imports. Chinese silicon and ferrosilicon producers do not have to comply with the stringent environmental regulations in place throughout North America and Western Europe. They have therefore enjoyed a significant economic edge over western producers. However, after the apparent start of tightening and enforcement of environmental regulations in 2005 and 2006, the trend may change. If this trend continues in the long term, the reactivation of United States silicon metal and ferrosilicon plants may be possible. Recent and future expected changes in the Chinese tax regime with respect to exports of energy-intensive products may also contribute to silicon and ferrosilicon price increases worldwide.

Electra Gold Ltd produces approximately 120 000 tonnes of geyserite (silica material with minor clay) from its Apple Bay deposit (Figure 3 and 8) which it ships to the Ash Grove Cement Company's cement plant near Seattle. During the 2006, Lehigh Northwest Cement Limited mined 30 500 tonnes of geyserite from the Monteith Bay quarry on western Vancouver Island to supply its cement plant in Delta. Lafarge Canada Inc mined about 5000 tonnes of sil-

Figure 8. Apple Bay geyserite (silica material with minor clay) deposit, Electra Gold Ltd, Vancouver Island.

ica-alumina material from the Buse Lake deposit, as feedstock for its Kamloops cement plant.

Most large, glass-making and silicon/ferrosilicon-grade silica resources are in the southeastern and central part of the province (Simandl *et al.*, 1994). Any large silica deposit located along the coast of British Columbia would be a prime candidate to supply the glass plants in the Pacific Northwest of the United States (Simandl, 2006).

Clay and Shale

Sumas Shale Ltd is scheduled to produce around 500 000 tonnes of shale, clay, conglomerate and sandstone from their Sumas shale quarries. The clay with the highest alumina content is used by Clayburn Industries Ltd for production of their insulation and refractory bricks and castable products, which are exported worldwide. Clayburn Industries Ltd also produces residential (common) bricks. Lower grade clay, sandstone and conglomerate are used for feed at Lafarge's cement plant in Richmond.

Sumas Clay Products Ltd produces small quantities of ornamental and specialty-facing bricks at their historic plant located near Abbotsford.

The Lang Bay site, which previously received lots of attention as potential source of clay and construction materials, is expected to be subject of a small drilling program in late 2006.

Pacific Bentonite Inc is extracting high-alumina material from its Decora deposit, located in the Hat Creek area. Most of this material is currently used for cement production by the Lafarge Cement plant near Kamloops, however, the company is aggressively developing new markets.

Medical Clays

Ironwood Clay Company Inc is the largest producer of cosmetic/medical clay in BC and the source of their raw material is De Cosmos Lagoon on Hunter Island. There was no reported clay extraction during 2006. Precision Laboratories Ltd of Surrey also started production of medical/cosmetic clay products. Similar material is now produced and marketed by Carrie Cove Cosmetics of Comox Valley for medicinal and cosmetic applications. It is also expected Glacial Marine Clay Inc will be producing clay for specialized hydroponics applications, and Robert Davie has another undeveloped clay deposit on King Island. The market for cosmetic/medical clay is limited but the processed product may retail up to $100 per kilogram. The market for specialized hydroponics clays is less stringent and larger.

Diatomite, Zeolite and Bentonite

Absorbent Products Ltd produces domestic and industrial absorbents. Most of the raw materials used in the company's line of products come from the Red Lake fuller's earth deposit near Kamloops and the Bud bentonite deposit in the Princeton area.

Zeo-Tech Enviro Corp has optioned its Bromley Creek zeolite mine to Heemskirk Canada Ltd, which mines, processes and markets industrial minerals to a variety of markets in North America including the oil and gas sector. Zeo-Tech plans to re-evaluate the lower quality Sunday Creek zeolite deposit, which was previously owned by Canmark Resources of Vancouver.

Heemskirk Canada also acquired the Ranchlands Z-1 quarry near Cache Creek from Dynatek. The two deposits service slightly different markets, so production from both should not affect the Cache Creek production appreciably. The Cache Creek deposit was not mined during 2006, however, during 2007 the limited stockpiled ore will be shipped to the processing plant in Lethbridge, Alberta.

Industrial Mineral Processors of Calgary, Alberta plans to move its plant, located in Ashcroft, to its Z-2 mine site

Limited exploration took place at the Crownite diatomite property near Quesnel. The geology of the promising Manual Creek zeolite occurance is summarized by Church (2006). Further laboratory work is needed to characterize lateral variations in cation exchange properties of the zeolite-bearing horizon. Drilling and trenching is needed to establish lateral continuity of the mineralization.

Dimension Stone

Westcoast Granite Manufacturing Inc in Delta, Margranite Industries in Surrey, Matrix Marble Corporation in Duncan, Hardy Island Granite Quarries Ltd, Bedrock Granite Sales & Stone Veneers and Kettle Valley Stone Company are the main dimension stone producing companies in British Columbia.

Margranite processes both imported and British Columbia granites. It provides nine local granite varieties, from at least three quarries located along the East Anderson River, Beaverdel and the Skagit Valley areas.

In 2006, Matrix Marble Ltd concentrated on processing materials at its plant near Duncan, but it also extracted blue and white marble from its Tahsis quarry near Tlupana Bay. The company also installed a polishing line for their marble slabs and will be selling 5½x9' slabs of the Vancouver Island Marble in a variety of thicknesses.

Hardy Island Granite Quarries Ltd (Figure 9) extracted about 3500 tonnes of stone this year and the product was sold through Bedrock Granite Sales and Stone Veneers in Coquitlam, BC. Bedrock Granite Sales & Stone Veneers processed the granite from Hardy Island and mined and processed so called 'andesite' from Haddington Island. It also processed and marketed a variety of volcanic rocks including basalt and rhyolite that are mined by producers in the Whistler area. Near Kelowna, the Kettle Valley Stone Company produced flagstone, ashlar, thin veneer and landscape rock products from several quarries.

Huckleberry Stone Supply Ltd of Burnaby and Mountain High Properties Ltd of Pemberton produced basalt from small quarries near Whistler. Garibaldi Granite Group Inc, which operated a stone-processing plant in Squamish and a couple of nearby quarries, closed in 2005.

Revelstoke Flagstone Quarries, Kootenay Stone Centre, Gerex Industries in the Nelson area and other small operators in the West Kootenays quarried flagstone. Small flagstone quarries were also opened in the North Thompson and Golden areas. In 2004, Green Rock Holdings Ltd quarried a limited tonnage of attractive green slate from its Dome Creek deposit near Highway 16, east of Prince George, but the quarry has been dormant ever since. Flagstone was also produced from the Aldridge Formation by Golden Rock Products Inc in the Kimberley area, southeastern British Columbia. Attractive red-purple slate/shale for flagstone applications was produced by Rocky Moun-

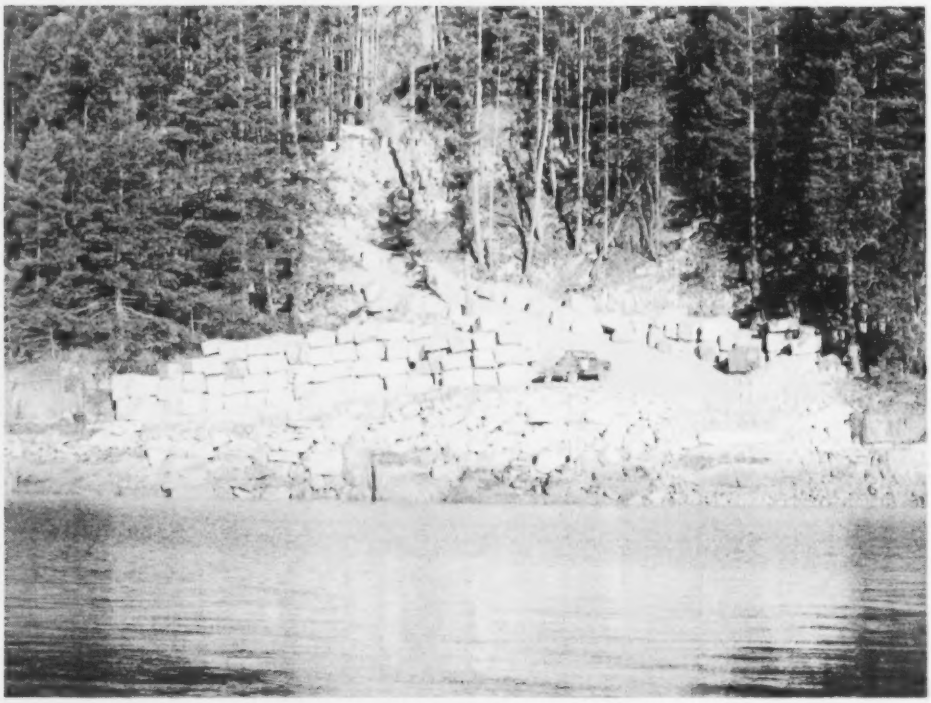

Figure 9. Hardy Island Granite (granodiorite) - blocks ready for shipping (flat bed truck for scale).

tain Tufa, which also produced about 2500 tonnes of tufa, mainly for landscaping.

On Vancouver Island, K2 Stone Quarries Inc, Van Isle Slate and San Juan Quarries Ltd are offering variety of veneer products, stepping stones and flagstones in a wide range of thickness.

A new flagstone deposit consisting of attractive beige-yellow tuff was discovered by Don Sandberg approximately 10 kilometres east of Beaverdel. A number of small flagstone operations started up in the Prince George area, including a small deposit of attractive and highly fossiliferous limestone.

Pumice, Tephra and Lava Rock

In 2005, Crystal Graphite Corporation purchased the Nazko lava rock quarry, west of Quesnel, from Canada Pumice Inc. The company produced about 30 000 cubic metres of tephra that year. In early 2006 Crystal Graphite went into receivership, but late in the year, a new entity called Lightweight Advanced Volcanic Aggregates Inc purchased the property and resumed shipping material from the site. The material is used for landscaping, sporting facilities, growing and filtration media, and lightweight aggregate applications.

Great Pacific Pumice Ltd is shipping a variety of pumice-based products from its Pum property on Mount Meager, north of Pemberton. Annual production varies from 10 000 to 12 000 cubic metres, but in 2006 the company expected to exceed this range. Garibaldi Aggregates Ltd applied for a permit to bulk sample pumice from its property, which is located near the Pum deposit.

Recently, George Wollanski acquired a property in the Falkland area from which he could produce three, colored varieties of vesicular basalt which is marketed as a lava rock for landscaping.

Slag

Pacific Abrasives and Supply Inc are producing granulated slag that accumulated during the operation of the long abandoned Granby smelter near Grand Forks. This material is used mainly for sandblasting at major shipyards and for roofing granules. The company also supplied slag to Roxul (West) International Inc in Grand Forks.

Slag was also extracted and shipped from Anyox by Tru-Grit. This slag is used mainly as an abrasive and as one of the raw materials for cement production in the Vancouver area and in the Pacific Northwest of the United States. Sized slag from Anyox is also used as roofing granules.

Teck Cominco Ltd is a major slag producer at its Trail smelter, which it markets mainly for cement production and abrasive applications. In 2002, the company converted one of the old furnaces into a second fuming furnace. The use of two furnaces doubles the fuming time and improves the quality of the slag by lowering the base metal levels in the final product.

Slag derived from production of forged steel mill balls by Moly-Cop Canada of Kamloops is used as source of iron for the manufacture of cement by Lafarge Canada at their Kamloops plant.

Magnetite

Craigmont Mines Joint Venture annually produces between 60 000 and 70 000 tonnes of magnetite for industrial applications, by processing the Craigmont Mine tailings. The company supplies most coal producers in western Canada with heavy-media material for their processing plants. The company has limited reserves, so to satisfy long-term demand it is considering a variety of stand-alone projects and joint ventures.

During 2005, a junior company sold approximately 4500 tonnes of magnetite from Iron Ross magnetite deposit, located approximately six kilometres south of Sayward (Simandl *et al.*, 2006b). Sales from this source were not reported for 2006. Benson Magnetics Ltd is investigating the feasibility of installing a 25 000 tonne per year plant near Benson Lake, on Northern Vancouver Island. The company also plans to examine the tailings of Iron Crown deposit on Vancouver Island. Texada Quarrying started to stockpile by-product magnetite from its limestone quarry located on Texada Island.

The Rob-Roy magnetite deposit on Vancouver Island was expected to be sampled in late 2006 by a junior company. The Mag prospect, located near Nelson was covered by a ground magnetic survey, but no additional work was done to establish its potential as source of magnetite.

A review of the magnetite market in British Columbia is provided in Simandl *et al.* (2006b).

Barite

British Columbia is known for extensive barite resources, which are commonly associated with the lead-zinc mineralization. Most of these resources are of extensive stratiform, sediment-hosted barite variety (Paradis *et al.* 1999). The type example is Cirque deposit (Akie). Sediment-hosted, stratiform barite deposits with low base metal content, such as those described in Nevada by Koski and Hein (2003), are rather uncommon in North America. Unless sulphide-free barite zones are identified, or barite is produced as byproduct of base metal mining, the barite from large, local deposits would have to be upgraded using a flotation process to meet specifications of the oil and gas industry. Vein deposits (Hora 1996), similar to Parson mine located west of Invermere in southeast British Columbia, which was exploited for many years, are preferred targets for the smaller exploration companies. The ore is high-grade, with low base metal content and processing is relatively simple.

In 2006, Fireside Minerals Inc mined 12 000 tonnes of barite from a vein system 125 kilometres east of Watson Lake near the Alaska Highway, and the company expects substantially higher production in 2007. The product was used mainly by the British Columbia and Alberta oil and gas drilling industry. The property was the subject of an intensive exploration and development-drilling program. There was no activity at the vein-type deposit owned by Tiger Ridge Resources Ltd at Jubilee Mountain, west of Spillimacheen

In October 2006, Rock Creek Minerals Ltd, a wholly owned subsidiary of Zena Capital Corp, took a 40-tonne test sample from the Lapin deposit, which is near Bridesville. Bulk sampling of zone B of this deposit, interpreted as a stratabound, sediment-hosted barite deposit, is expected late in 2006. The company indicates that the ore is high grade with a low base metal content and does not anticipate a need for flotation. Barite occurrences in British Columbia are compiled in Butrenchuk and Hancock (1997).

Barite that can satisfy the specifications of the oil and gas industry without flotation may be in short supply in five years, despite extensive world reserves. The challenges to find clean, high density barite are reflected by the lobby efforts of United States barite producers, especially those based in Nevada, to have oil and gas drilling grade specifications modified from 4.2 to 4.1 g/cm^3 to extend their ore reserves (Dearing, 2006).

Fluorite

Parts of British Columbia contain known fluorite occurrences and have excellent potential to host economic deposits. For example, the northerly trending belt of fluorite showings located north of Liard Hot Springs has excellent exploration potential. Rexspar and Eaglet are other well-known occurrences. The Rexspar deposit, which may contain fluorite as a co-product was subject to background environmental studies in 2006. It is possible that additional work will take place at Rexpar during 2007. Available technical data on the Eaglet deposit, which belongs to Freeport Resources Inc, is currently under re-evaluation, but the deposit was not subjected to a major field program in 2006. Fluorite occurrences in British Columbia are described by Pell (1992).

Until recently fluorite, also referred to as fluorspar or acidspar, was in oversupply globally. In 2000, China exported over a million tonnes of fluorite, however, by 2005 its exports dropped to 730 000 tonnes due to increasing domestic needs. In 2006, the supply and demand of fluorite appear to be in balance with most of the producers running at over 90% of their production capacity (Tran, 2006). Fluorine containing chemicals, used in refrigeration, are under environmental pressure (Simandl, 2003), however, some of the substitutes for hydrochlorofluorocarbons (HCFCs) that are supposed to be phased out in United States by 2010, are being replaced by more environmentally friendly (less stable) fluorocarbons that may have even higher fluorine content per molecule than the materials they are replacing (Tran, 2006). Therefore, fluorite demand may not be as severely affected as was originally expected.

Perlite and Vermiculite

Coarse-grained, mica-rich fenite was encountered during the exploration for niobium and tantalum on the Upper Fir deposit, located in the Blue River area. Field tests indicate that the major constituent of this fenite is vermiculite (Figure 10). Vermiculite deposits associated with carbonatites, such as this one, are favourable exploration targets because they are not known to contain asbestos-type minerals. Asbestos-type particles have been identified with some ultramafic-hosted vermiculite deposits, such as at the Libby deposit, which gives rise to health concerns (Simandl *et al.*, 1999).

There has been no major exploration program for perlite in British Columbia since BBF Resources Inc extracted approximately 400 tonnes of perlite from the Frenier Deposit, southwest of Williams Lake. According to the company, perlite was used to produce commercial-size samples of the product for horticultural applications.

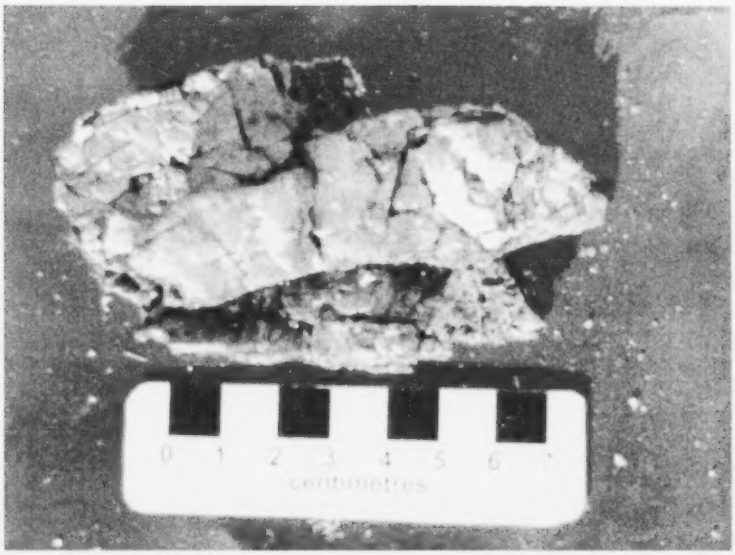

Figure 10. Expanded vermiculite; scale in centimeters. Upper Fir deposit, Blue River Area.

Most of the known perlite occurrences in British Columbia are described by White (2002). Current demand for perlite and vermiculite in BC is satisfied by imports.

Jade, Sodalite and Nepheline Syenite

Jade West Resources Ltd and its affiliated company, Polar Gemstones Ltd, remain the main nephrite producers in British Columbia. In 2006, they produced about 200 tonnes of nephrite from the Kutcho Creek area and explored for an extension of the Polar deposit in the Serpentine Lake area of northwestern BC. Jade West also operated a warehouse and processing facility in south Surrey. The company is looking for partners to set up a facility to produce nephrite tiles.

Companies that extracted, processed or marketed nephrite were Cassiar Jade Contracting, Cassiar Mountain Jade, Glenpark Enterprises Ltd, King Mountain Jade and others. A number of individual prospectors were also active in exploration and processing of nephrite in British Columbia. Eagle Plains Resources Inc extracted samples of ornamental sodalite from the Moose Creek area, within the Ice River group of mineral claims, 45 kilometres east of Golden. The property also contains a large zone of nepheline syenite, which is a part of the Ice River Complex, and the company is looking for partners to develop this resource.

SUPPLEMENTARY CEMENTITIOUS MATERIALS AND BLENDED CEMENTS

The use of blended cements is rapidly increasing in North America, and they commonly contain up to 5% finely ground limestone while in other parts of the world this percentage is higher. The use of other supplementary cementing materials in blended cements is also on the rise, largely due to the high cost of energy needed to produce Portland cement and the desire of the industry to reduce CO_2 emissions. Natural pozzolans do not need to be calcined. By using materials that do not require calcinations, substantial fuel savings are achieved, there is no CO_2 released from the crystal structure of these supplementary cementiceous minerals. The CO_2 release per tonne of cement is further reduced because less fossil fuel is burned. Natural pozzolans were in use in Greece, Italy, Germany, Spain and many other parts of the world long before the Portland cement was invented. The term pozzolan designates any material regardless of its origin, which reacts with lime to produce cementitious material. Volcanic glasses, pumice, certain volcanic tuffs (some of them zeolite-bearing) and opaline silica are typical examples. Natural pozzolans are inexpensive materials; therefore, economic deposits must be located within a reasonable of a market. Diatomaceous earths that consist largely of opaline or amorphous silica may also have excellent pozzolanic properties; however, they are commonly associated with clays and need to be calcined to increase their reactivity with lime. Some of the man-made, generally unwanted byproducts of industrial activity, including fly ash, condensed silica fumes and ferrous and nonferrous slags have properties similar to natural pozzolans. Fly ash is probably the most widely used synthetic pozzolan throughout North America and Europe. If coal is used on a larger scale to generate electricity in British Columbia, then locally derived fly ash, produced by flue gas desulphurization, could also be incorporated into the cement supply-and-demand equation (Simandl, 2006). In many cases, cement producers prefer synthetic rather than natural pozzolans when they have a choice, because synthetic pozzolans tend to be constrained in chemical composition and physical properties and they are less expensive (commonly considered as waste).

HIGH TECHNOLOGY MINERALS

In 2006, Commerce Resources Corporation trenched and drilled (17 holes) the Upper Fir carbonatite in the Blue River area. The analytical results from the first Upper Fir drillhole, released in October 2006, show comparable or higher grades to the nearby Fir and Verity carbonatite bodies. Fir ferrocolumbite and pyrochlore-bearing carbonatite appears flat lying, and has been outlined over an area of 425x325 metres. Resource estimates for Fir deposit are reported at 5.6 million tonnes of indicated and 6.7 million tonnes of inferred, both grading 203.1 g/t tantalum pentoxide and 1047 g/t niobium pentoxide (Verzosa, 2004). The company's 2001 resource estimate for the nearby Verity deposit was 3.06 million tonnes containing 196 g/t tantalum pentoxide, 646 g/t niobium pentoxide, and 3.2% phosphate (McCrea, 2001). The mineralogy of selected samples from the Fir and Verity deposits was summarized by Simandl and Rotella (2002) and additional background information regarding the tantalum market is presented in Simandl (2002c).

David Pighin of Cranbrook reported highly anomalous concentrations of rare earth elements in heavy mineral concentrates containing monazite, goyazite in stream sediments and soils from the Fen occurrence, which is located about 60 kilometres northeast of Canal Flats, in southeast British Columbia. Galena, sphalerite, strontianite and barite were also identified in the concentrates. The exploration significance of these anomalies remains to be established, however, their metallogenic significance should not be overlooked. Goyazite, a relatively uncommon mineral, was reported in the same setting along the Kicking Horse Rim, where it occurs in combination with fersmite (Birkett and Simandl, 1992) and euclase.

EXAMPLES OF VALUE-ADDED MATERIALS DERIVED FROM LOCAL RAW MATERIALS

British Columbia is currently going through a "construction boom" that many believe will last at least until the 2010 Olympics. The three selected examples, described below, involve transformation of low-cost raw materials to key materials used in construction. In all of these cases, the increase in value is sufficient to permit export and justify transportation over distances of hundreds if not thousands of kilometres.

Cement

The value of cement produced in British Columbia is estimated at over CAD$300 million. The Lafarge Canada Inc plant and the Lehigh Northwest Cement Limited plant are state-of-the-art operations, located south of Vancouver, in Richmond and Delta, respectively. The Lafarge plant has an official production capacity of 1.15 million tonnes of cement, but the 2006 production will most likely exceed the designed capacity. According to Lafarge, the company will be able to satisfy its clients in British Columbia. However, some of the cement demand in Washington State, which was traditionally satisfied by the Richmond plant, will have to be replaced by imports from elsewhere. Lafarge's cement plant in Kamloops forecasts production at about 220 000 tonnes of cement. The Lehigh cement plant in Delta, south of Vancouver, operated near its maximum designed capacity of 1.15 million tonnes per year. The production from this plant is shared nearly equally between consumers in British Columbia and in US Pacific Northwest (Simandl, 2006).

Mineral Wool

The insulation/mineral wool manufacturing plant in Grand Forks operated by Roxul (West) International Inc maintains innovative technology (Figure 11) and since 1999, the company has invested $30 million in improvements of its operations. The main source of rock for the plant was the Winner diorite quarry in the Greenwood min-

Figure 11. Rock wool plant, Roxul (West) International Inc in Grand Forks.

ing camp, 4 km south of the former Phoenix mine. In 2006, approximately 50 000 tonnes of diorite are expected to be mined and crushed there. The material from the Winner Quarry is supplemented by talus material from Cannon Creek. Slag used by Roxul is supplied by Pacific Abrasives and Supply Inc from Grand Forks, while dolomite is currently imported from the United States.

Roofing Granules

In October 2001, IG Machine and Fibers Ltd, a subsidiary of IKO Industries Ltd, opened the Ashcroft basalt quarry and roofing-granule plant. This state-of-the-art plant currently produces at about 70% of its rated capacity of 500 000 tonnes of granules per year, in nine distinct colours. Basalt is quarried, crushed, sized and coloured on site, prior to shipping to IKO Industries shingle plants in Sumas (Washington), Calgary, Winnipeg and Chicago.

SUMMARY

Most industrial minerals show steady growth in demand and are not subject to rapid, demand fluctuations to the same extent as the metal markets. This sector has shown steady growth over the last fifteen years. This growth has included more sales to international markets, including even low-cost construction and cement raw materials in the last several years.

Supplementary cementitious materials, which do not require calcining, are starting to benefit from industry efforts to reduce cement associated CO_2 emissions.

Existing and aspiring aggregate producers along the coast of British Columbia are enthusiastic regarding the potential to carve out substantial portions of the California aggregate market. This reflects the increasing costs for aggregate in the United States and improved BC facilities for shipping aggregate by sea. The limestone operations on Texada Island are increasingly supplying the California and Lower Mainland crushed stone markets as well.

As China reduces exports of some industrial minerals, this is expected to open development opportunities for a variety of industrial minerals that are known to occur in British Columbia, including barite, fluorite and possibly silica and magnesite.

There is an existing market for glass-grade silica raw material which may be discovered along the coast of British Columbia.

The expansion of the British Columbia coal industry is having a positive impact on the magnetite markets, a commodity that is used in coal beneficiation.

Dimension stone producers and processors based in British Columbia are facing stiff competition from Chinese and other country stone imports. However, there are opportunities in niche markets and the nephrite jade market is brisk. There are a number of successful local flagstone and veneer producers that are introducing more and more British Columbians to stone products.

Currently all perlite and vermiculite demand in British Columbia is met by imports. In the short term, there is a limited opportunity to develop local deposits but the time may be ripe to build a perlite expander to satisfy lower mainland demand, even if the raw materials were imported.

The future of the industrial minerals industry in British Columbia remains bright, and the value-added processing of industrial minerals plays an increasingly important role in the ability of local industrial mineral producers to be competitive in international markets.

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